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Automatic Building Extraction Using Advanced Morphological Operations and Texture Enhancing

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Abstract

Satellite images are promising data sources for map generation and updating of available maps to support activities and missions of government agencies and consumers. Full exploitation of these data sources depends on automatic techniques for object extraction from satellite imageries. Buildings, as one of the important man-made objects are subjects of concern to be extracted automatically. In this paper, Mathematical Morphologic operator has been used to close and eliminate the unwanted objects over the building roofs. The proposed approach involves several advanced morphological operators among which an adaptive hit-or-miss transform with varying size and shape of structuring element is used to determine the optimal filtering parameters automatically. After morphological operations, based on the texture parameters of buildings which are able to differentiate buildings from nearby non-building regions, buildings are extracted.

Keywords: Mathematical Morphology; Hit-or-Miss Transform; Texture parameters; Automatic Building Extraction.

1. Introduction

Automatic building extraction is being increasingly used for urban planning and management. Therefore, it has been the focus of intensive research for the last decade. Traditionally, the building

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boundaries are delineated through manual digitization from digital images in stereo view using the photogrammetric stereo plotters. However, this process is a tiresome and time consuming task and requires qualified people and expensive equipments. For this reason, building extraction using the automatic techniques has a great potential and importance.

In the previous studies conducted by Mayer (1999), Sowmya and Trinder (2000), Baltsavias (2004) and Brenner (2005) the automatic and semi-automatic building extraction approaches were extensively reviewed. Mathematical morphology (MM) is a technique for analysis and processing of geometrical structures, based on set theory, lattice theory, topology, and random functions.

Traditional remote sensing image classification methods are based on pixel, considering more spectral information but have no image texture feature, context semantic features. Due to the limitations of pixel-based classification method in high-resolution remote sensing image, combining the texture features of high resolution remote sensing image are used for feature extraction. Ming Dong-ping, etc. proposed information extraction methods based on primitive block which gives a good combination of features in the shape, size, gray and other features and increase the application of remote sensing information and automation and intelligent level [2].

2. Mathematical Morphology

MM is a branch of digital image processing and analysis originating from the work of Matheron (1975) and Serra (1982). The central idea of MM is the process of examining the geometrical structure of an image by matching it with smaller patterns at various locations in the image. [3]

2.1 Operators

In MM there are two elementary morphological operators: dilation and erosion, from which the other operators and tools can also be formed. [3]

2.1.1 Dilation Operator

Dilation is the process of expanding and growing regions around the positive pixels of an image, I, using a structuring element, S. For each position that the structuring element is at, the maximum value contained within the structuring element (superimposed upon the input image) is used as the pixel value for the output image.

2.1.2 Erosion Operator

Erosion shrinks and wipes the regions out. The process is exactly the same as for the dilation operator, save that instead it calculates the minimum.

2.1.3 Opening Operator

Opening is the process of separating and isolating small regions of an image from larger ones, and simultaneously eliminating information contained on small scales.

2.1.4 Closing Operator

Closing is the process of filling-in holes in the pixel distribution, and joining together previously separate image features. Mathematically, it is dilation followed by erosion.

3. Texture Extraction

Main objective of a texture/shape extraction process is to extract the prominent feature of an image. Texture is an area property and is exemplified by features similar to roughness, variability, repeatability, directionality and more, defined over a certain spatial extent, when compared to colour. The energy distribution in the frequency domain is employed by numerous techniques for texture retrieval and classification in order to recognize texture. [8] Grey-Level Co-occurrence Matrix (GLCM) is a tabulation of how often different combinations of pixel brightness values (grey levels) occur in an image. Most texture calculations are weighted averages of the normalized GLCM cell contents.

4. Methodology

The methodology as shown in fig.1 we propose to extract building objects from VHR-images rely on the use of binary mathematical morphology operators which are based on set theory [9] and texture. The overall approach we propose is composed of five main steps.

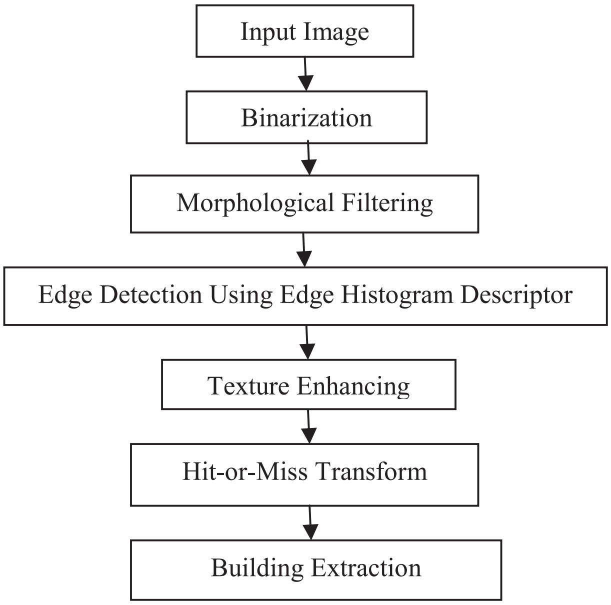

Fig. 1 Methodology

4.1 Generation of binary images

As we use binary morphological operators, panchromatic (or grey level) input image I cannot be processed directly. In order to obtain a binary image B, the simplest solution is to choose arbitrarily a threshold value T (depending of the image), and classify all pixels as white or black according to whether the pixel values exceed or not this threshold,

$$B(x) = \begin{cases} 1 \text{ if } I(x) \geq T \\ 0 \text{ otherwise} \end{cases} \tag{1}$$

4.2 Automatic morphological filtering

The aim of this filtering is to remove objects whose size is lower than the minimum size of a building in the raw image. The filtering used is a morphological opening defined as a combination of erosion and dilatation:

$$\gamma_S(I) = (I \ominus S) \oplus S \tag{2}$$

where the size and the shape of the structuring element S are parameters of prime importance.

4.3 Edge Detection

Then, edges are detected using Edge Histogram Descriptor method where edges in the images are categorized into 5 types: vertical, horizontal, 45- degree diagonal, 135-degree diagonal and non-directional edges. This type of edge detector has improved the result over commonly used Sobel or Canny edge detectors

4.4 *Texture Enhancing*

GLCM calculates how often a pixel with gray-level value i occurs either horizontally, vertically, or diagonally to adjacent pixels with the value j, where i and j are grey level values of the image. From GLCM, texture parameters can be obtained.

4.5 *Hit–or–Miss Transform*

In mathematical morphology, hit-or-miss transform is an operation that detects a given configuration (or pattern) in a binary image, using the morphological erosion operator and a pair of disjoint structuring elements. We propose to use the Hit or Miss Transform (HMT) as shown in fig.2 which consists in a double erosion of the image I and its complement I^c (i.e. the background) with two disjoint structuring elements E and F. This transform is particularly useful for template matching and is defined as:

$$\begin{aligned} I \circledast (E,F) &= (I \ominus E) \cap (I^c \ominus F) \\ &= \{x : ((E_x) \subseteq I) \wedge ((F_x) \subseteq I^c\} \end{aligned} \quad (3)$$

where a pixel x is keep as long as it ensures a successful match of both the ES E with I and the ES F with IC, both ES being centred into x.

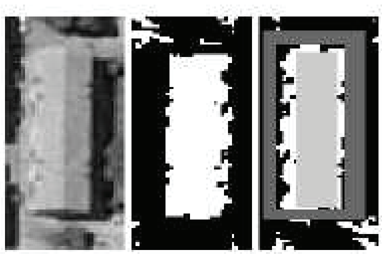

Fig.2 Relevance of the HMT for imperfect building shapes: original image (left), binary image (middle), and application of the HMT (right). The two SE used in the HMT appear in light grey (for the foreground) and dark grey (for the background), the uncertain area is located in between.

5. Results and Discussion

The methodology is applied over two sets of images to analyse the results in a better way. The input image chosen consists of two regions which are a part of Kanchipuram district as shown in fig.3a and part of Anna University, Chennai as shown in fig.3b where some parts of buildings are covered by trees which suits our requirement.

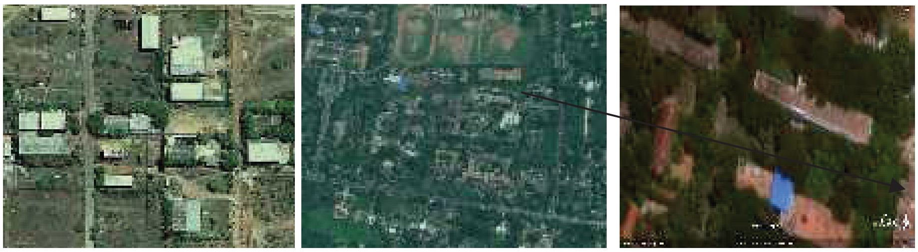

Fig.3. (a) Input image 1-Kanchipuram district (left); (b)Anna University (middle);
(c)input image 2- part of Anna University, Chennai (right)

The input image 1 is converted into a binary image as shown in fig.4a as any grey scale image should be converted to binary image for morphological operations to take place. But this converted image contains noise. Hence it is further processed and morphological filtering as in fig.4b is done to remove the noise. After Morphological filtering, the edges are detected using edge histogram which avoids the edges of a building to be grouped with other buildings and precisely detect the building edges.

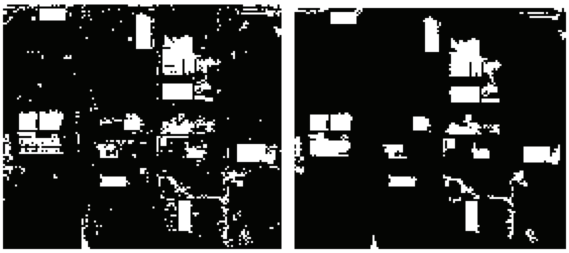

Fig.4. (a) Binary image (left); (b) Filtered image (right).

GLCM is determined and texture parameters such as contrast, energy, homogeneity and standard deviation are obtained.

The obtained texture parameter values from the image are

Contrast - 0.2662

Energy - 0.1938

Homogeneity - 0.8947.

Contrast value returns a measure of the intensity contrast between a pixel and its neighbour over the whole image. Contrast is 0 for a constant image. A value of 0.7200 represents that there are buildings and trees or other objects close together in the image. Energy returns the sum of squared elements in the GLCM. Value of 0.1012 represents that there are not as much changes detected in the corners of the image. If the energy value is high, changes in pixel values can be detected easily. Thus trees that are located near the buildings can be easily distinguished with the help of this property. Homogeneity returns a value that measures the closeness of the distribution of elements in the GLCM to the GLCM diagonal. A value of 0.7799 represents the uniformity in the distribution of elements.

HMT enables to eliminate some elements in the binary images that are not buildings (for instance, some shades). Thus, the number of objects existing in the HMT image is lower than the one existing in the filtered image. The texture parameters are then combined with morphological operations as regards to the shape of objects used during the geodesic reconstruction, it corresponds to the one of the elements present in the filtered image. The same steps are followed for input image 2 and thus buildings are extracted and the results are analysed.

The extracted buildings are shown in fig.5.

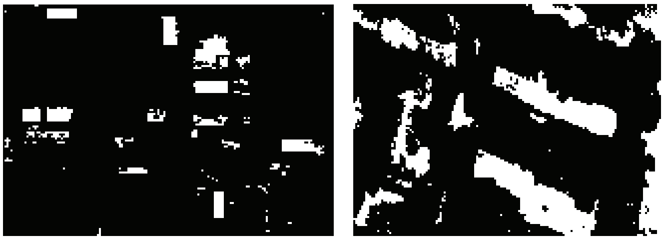

Fig.5. (a) Extracted buildings for input 1(left); (b) Extracted buildings for input 2(right).

6. Conclusion

Mathematical morphology offers some image processing tools which can be successfully used to solve urban remote sensing issues such as building detection in VHR images. In this paper, we proposed a morphological approach that deal with this problem. In this paper, a special case of buildings are chosen and buildings are extracted using advanced morphological operations and texture parameters. We extended the previous works by introducing a hit-or-miss transform after the filtering step. This morphological profile helps to define automatically the structuring elements used in the adaptive hit or miss transform. Thus, buildings are reconstructed and the outlines of buildings are obtained. By combining the texture parameters with morphological operations buildings that exhibit different texture which are sometimes not extracted by morphological operations are also extracted.

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